Commercialization of Military & Space Electronics - Conference

Commercial Off-The-Shelf (COTS) Program

Using Nondestructive Methods (C-SAM) for COTS PEMs Screening and Qualification

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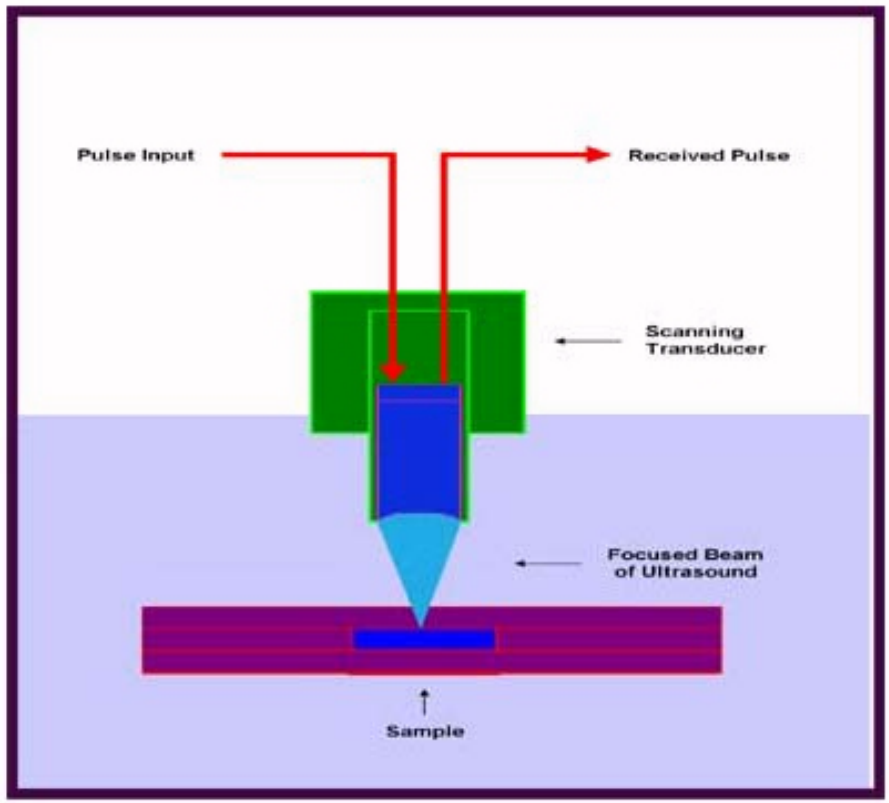
AGENDA:

- C-SAM Inspection
- Failure Mechanisms/Studies
- C-SAM Screening Method
- Test Data
- Reject Criteria/Failure Analysis
- Other Work
- Summary

The work was performed at Jet Propulsion Laboratory California Institute of Technology under contract to the National Aeronautics and Space Administration

C-SAM Inspection Characteristics:

- Nondestructive Method
- Ultrasound Signal
- Ceramics, Plastics, Metals
- Voids, Cracks, Delamination, Anomalies, Defects, Disbonds
- Relatively inexpensive
- Cheap Reliability Insurance



Possible Failure Mechanisms from PEM Delamination Based on Independent Studies:

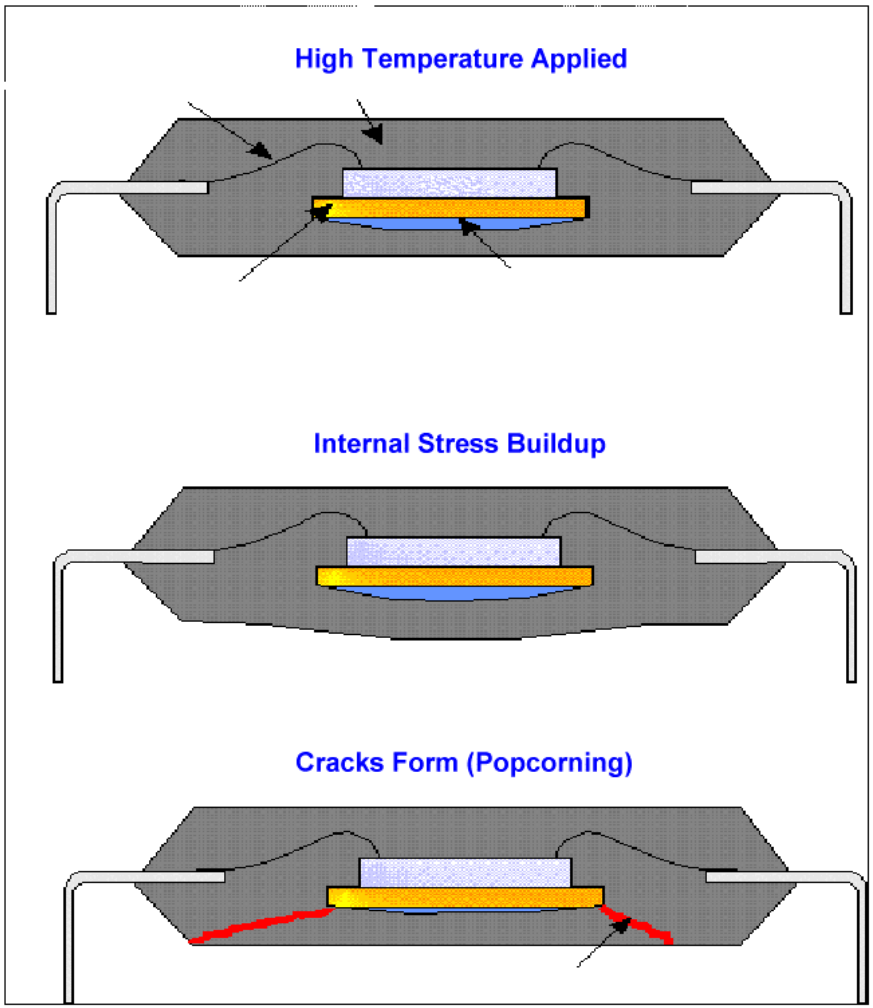
- Stress-induced passivation damage over the die surface
- Wire bond degradation due to shear displacement
- Accelerated metal corrosion
- Die attach adhesion
- Intermittent electricals at high temperature
- Popcorn cracking
- Die cracking
- Device Latch Up

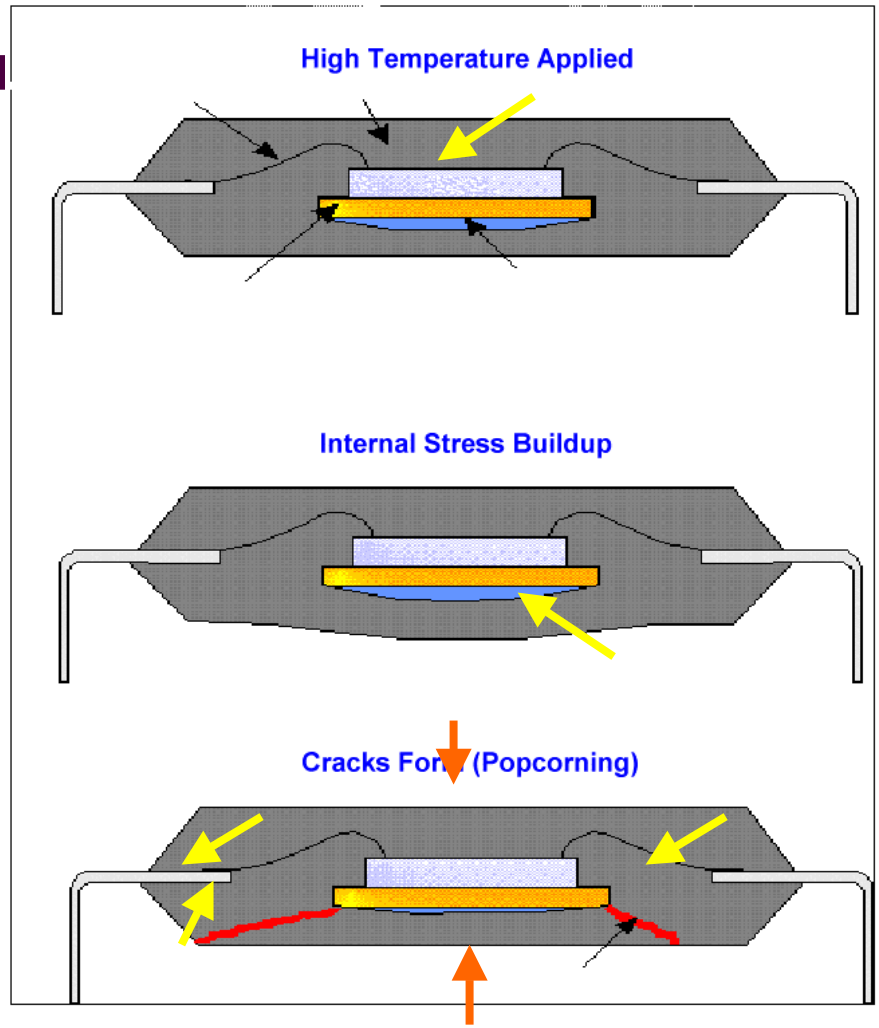
Eight Independent Studies on C-SAM Delamination /Reliability:

- Failure Criteria for Inspection Using Acoustic Microscopy After Moisture Sensitivity Testing of Plastic Surface Mount Devices; Alcatel Bell, Texas Instruments, Philips Semiconductor
- A Case Study of Plastic Part Delamination; ITT Aerospace/Communications
- The Application of Scanning Acoustic Microscopy to Control Moisture/Thermal Induced Package Defects; Texas Instruments
- C-SAM Analysis of Plastic Packages to Resolve Bonding Failure Mode Miscorrelations; Texas Instruments
- On the Role of Adhesion in Plastic Packaged Chips Under Thermal Cycling Stress; Siemens
- Relation Between Delamination and Temperature Cycling Induced Failures in Plastic Packaged Devices
- Correlation of Surface Mount Plastic Package Reliability Testing to Nondestructive Inspection by Scanning Acoustic Microscopy; Texas Instruments
- The Mystery of the Cracked Dice; Analog Devices

Popcorning Failure Mechanism from Internal Moisture

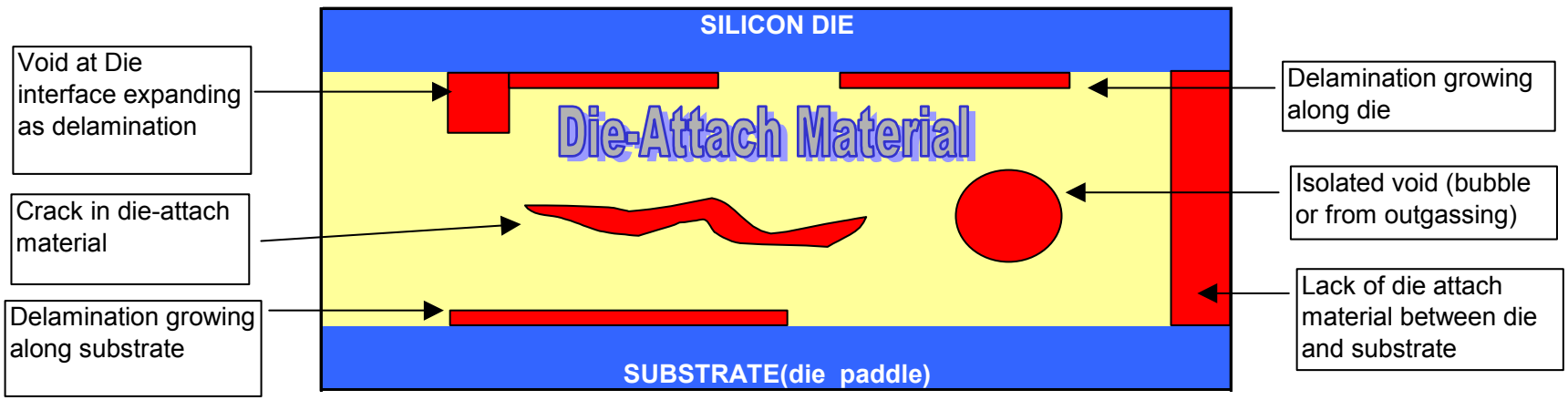
C-SAM Inspection Points for delamination which can accelerate entry of moisture/collection





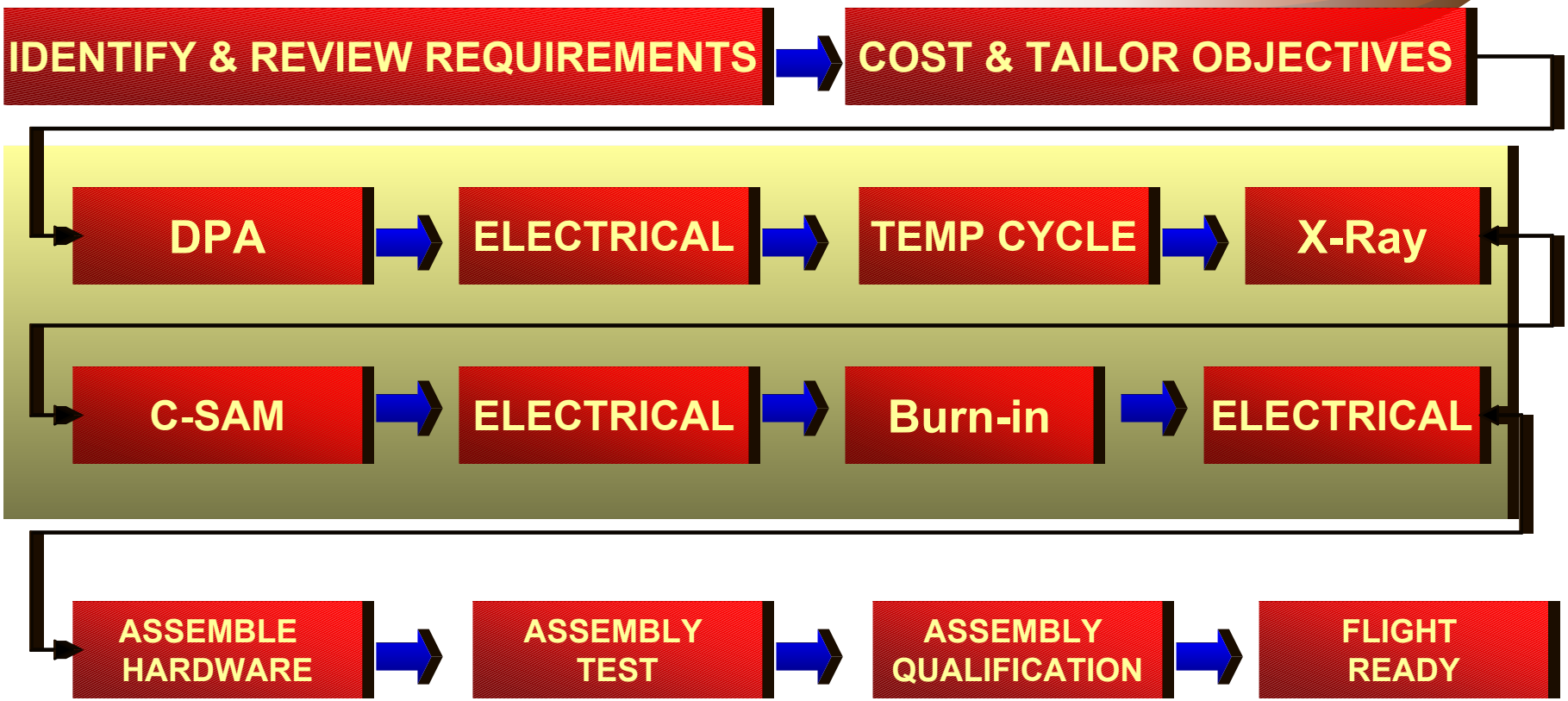
C-SAM Finds Hidden Defects

HIDDEN DEFECTS IN IC PACKAGES (PLASTIC) CAN AFFECT RELIABILITY



Die-attach material serves three functions: attach die to die substrate, conducts heat away from die, and absorbs some internal stresses.

C-SAM is Included in JPL's Full Part Level Screening



COTS^{++} Plastic Infusion Critical Screening Flow
(Tailored for Project application/mission requirements)

COTS^{++} Upscreening Rejects by Part Type & Vendor

	Amplifier- A	ADC- B	ADC2-B	DC-DC Con.-C	Voltage C-A	S.Regulator-B
DPA:	0/4	1/8	TBD	0/4	0/4	0/4
Incoming:	0/78	n/a	4/79	1/78	0/80	8/80
C-SAM:	**3/78**	**38/78**	**9/75**	**16/77**	**5/80**	**0/80**
Temp Cycle:	0/78	10/78	0/75	3/77	0/80	3/72
Burn-In:	0/78	3/68	0/75	0/74	0/80	9/69
QCI:	0/10	0/10	0/10	0/10	0/10	0/10
Total:	3/78	51/78	TBD	20/78	5/80	20/80

LOT by LOT Test Results:

CSAM Yields
06/12/2000

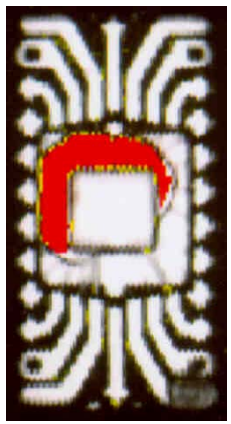
Part Type	Manufacturer	Yield
NPN Transistor 1	A	83%
Switching Diode	A	0%
NPN Transistor 2	A	100%
Zener Diode	A	50%
NPN Transistor 3	A	100%
Op-Amp 1	B	87%
Op-Amp 2	C	0%
Op-Amp 3	C	7%
Phase Detector	D	100%
MMIC	E	40%

Results are package/ vendor assembly dependent. Failed lots were replaced and retested.

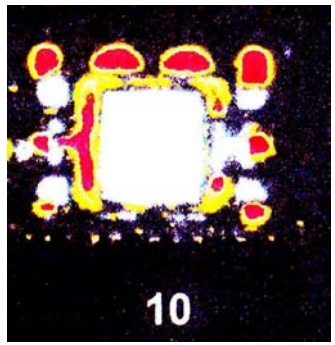
Lot sizes range from 15-30 parts each.

C-SAM Rejects (JPL examples): (Devices with >> 10% delamination in critical areas are suspect and are rejected)

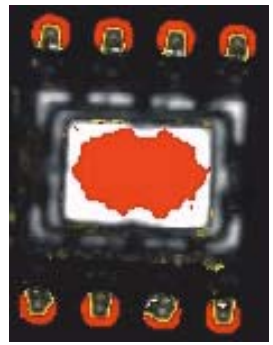
Reject



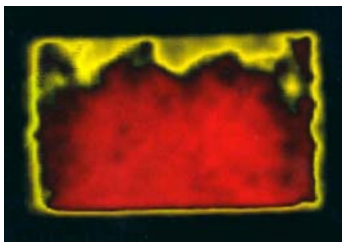
Reject



Reject



Pass*



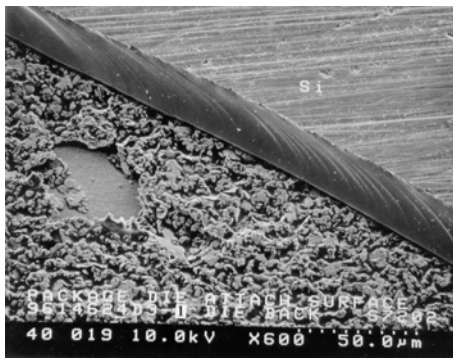
Reject

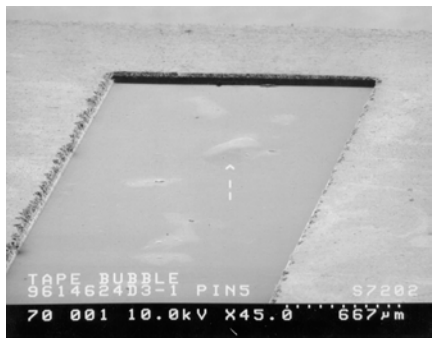
Reject

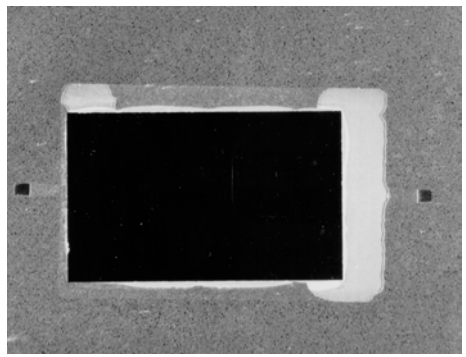
Pass*

*Delamination is not evident because of die top coating used by the manufacturer. (e.g. C-SAM limitation)

C-SAM Delaminations Confirmed by Failure Analysis: (JPL examples):





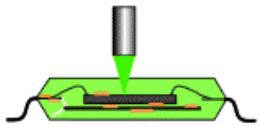
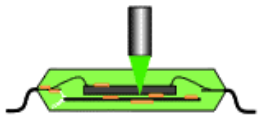
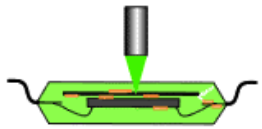
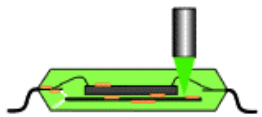
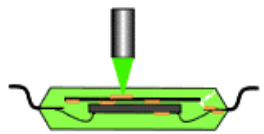
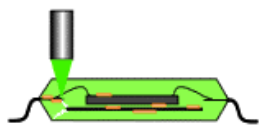
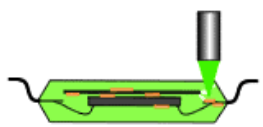
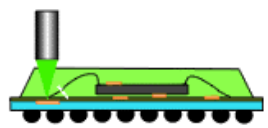
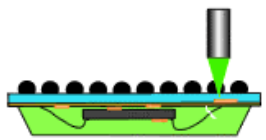
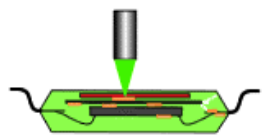


A. Die attach void at the heat sink surface

B. Bubble exists from Mylar tape near pin 5

C. Delamination and lack of adhesion between die and heat sink

Definitive results were found on six suspect problem areas submitted for analysis.

	Circuit Side Scan	Non-Circuit Side Scan
Type I Delamination: Encapsulant/Die Surface		
Type II Delamination: Die Attach Region		
Type III Delamination: Encapsulant/Substrate (Die Side)		
Type IV Delamination: Substrate/Encapsulant (Backside)		
Type V Delamination: Encapsulant/Lead Interconnect		
Type VI Delamination: Intra-laminate (Laminate Substrates Only)		
Type VII Delamination: Heat Sink/Substrate		

IC defect descriptions are now identified in J-STD-035

(Acoustic Microscopy for NonHermetic Encapsulated Electronic Components)

Source: Sonoscan Inc.

A New Failure Characterization Study

is Underway Utilizing Plastic Part C-SAM Rejects

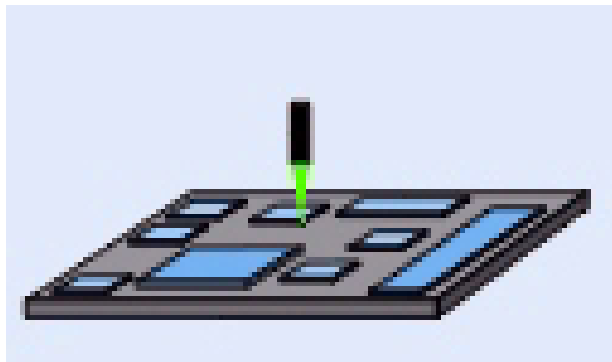
Objectives:

- Identify C-SAM reject parts by criteria(s)
- Measure Material Properties including sonic test, IR, X-ray
- Apply extreme temperature cycle stresses
- Repeat Material Properties Measurements including C-SAM at different intervals
- Identify all failure mechanisms and risk rate C-SAM rejects

A Failed Chip Scale Board Assembly is under investigation utilizing C-SAM inspection on components/board

Objectives:

- Identify component delaminations
- Identify board layer delaminations
- Make correlation to CSP package thermal cycle failures
  - CTE Mismatch
  - Package Proximity and Location on Board
  - Ball Bond Size and Location

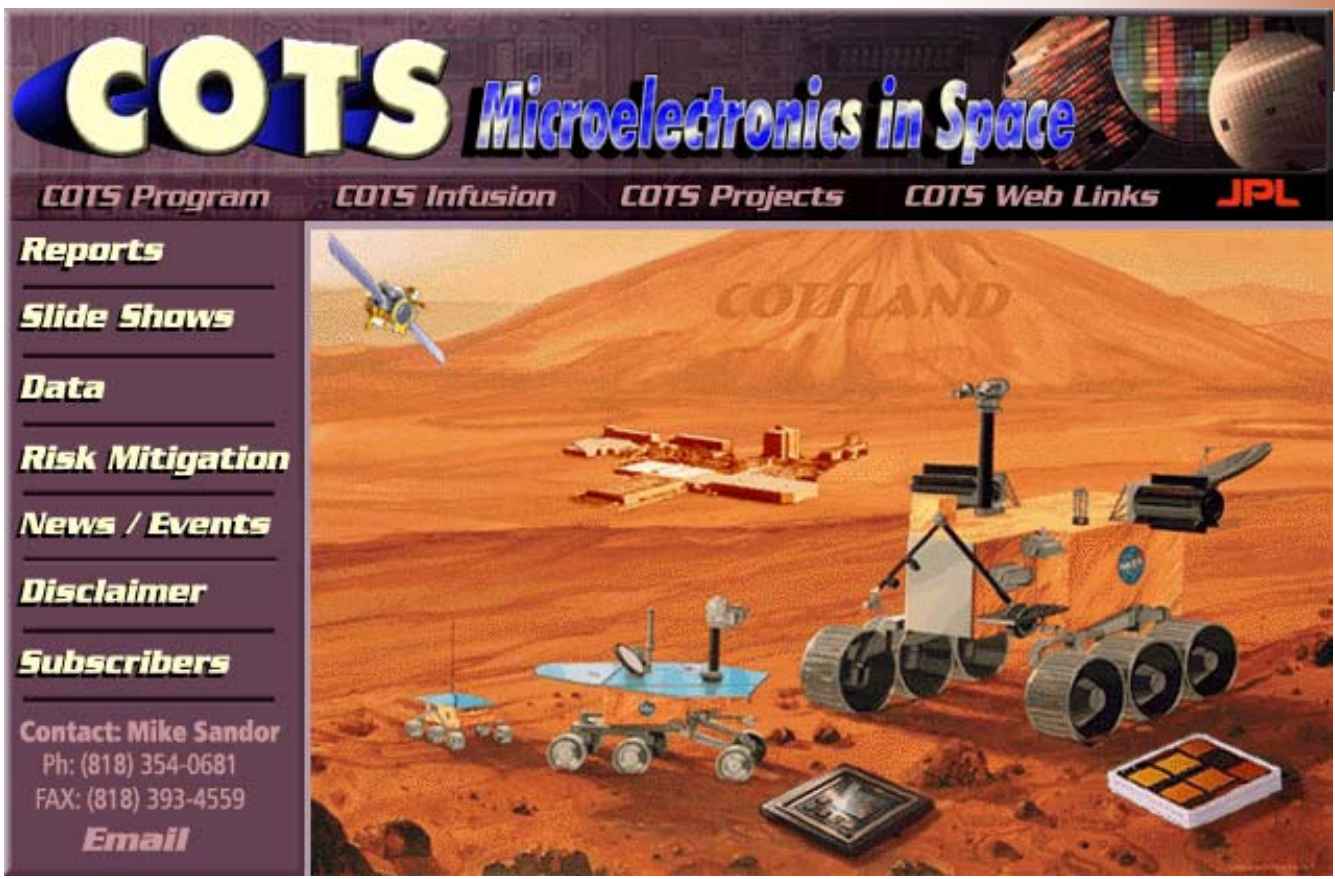


Summary:

- Some reported concerns/risks anticipated with using PEMs having evidence of delamination can be minimized and possibly eliminated with nondestructive AMI (acoustic microscopy imaging).
- JPL's existing screening flows for PEMs incorporates AMI 100% to enhance the reliability of parts used by JPL Projects when PEMs are the only choice available.
- Further investigations/studies are being conducted on individual components and board assemblies using AMI analysis. This information will provide more understanding of the correlation between delamination and component/ board failure mechanisms.

JET PROPULSION LABORATORY
Electronic Parts Engineering Office

Additional information can be found at:



http://cots.jpl.nasa.gov